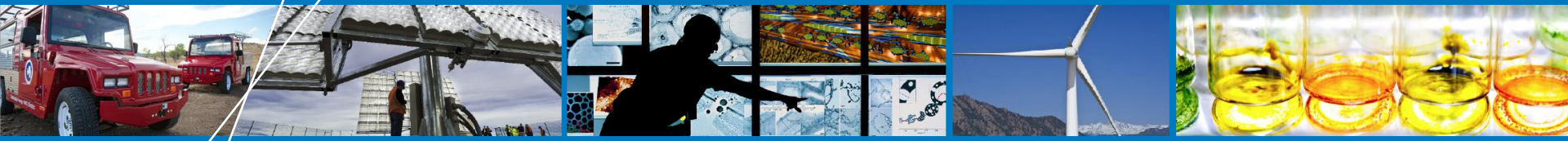
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

PVWatts®: Tips and tricks for the latest update



Nate Blair

July 9, 2014

What is STAT?

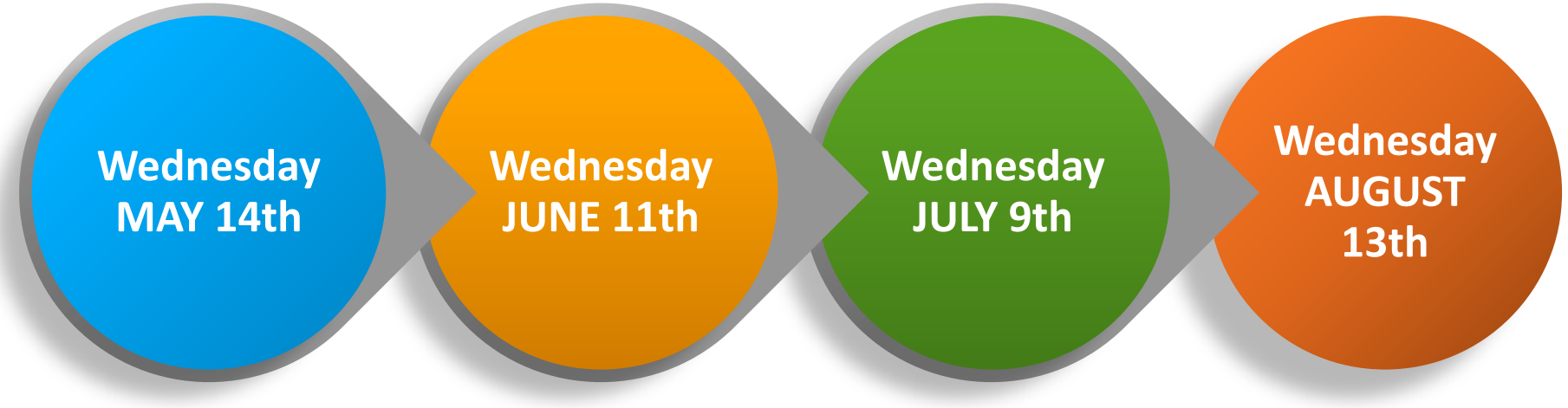
Solar Technical Assistance Team (STAT)

- **U.S. Department of Energy (DOE) Solar Technologies Office, in coordination with the National Renewable Energy Laboratory (NREL)**
- **Objective**
  - Provide current, credible information on solar policy, program, and regulatory choices to entities positioned to impact the policy environment through:
    - Basic solar education for new officials and staff
    - Partnerships to address specific challenges
    - Topical learning opportunities

To learn more, visit:
http://www.nrel.gov/tech_deployment/stat.html

DIY Solar Market Analysis Summer Series

2nd Wednesday of EVERY MONTH
Noon – 1 pm MST



- **Top Solar Tools:** What are they and how do they help policymakers?
- **Solar Resource and Technical Potential:** Finding, using, and making maps for decision makers
- **PVWatts: What's New?** Tips and tricks for the latest update
- **Community Solar Scenario Tool:** Learn to evaluate if a solar garden makes sense in your community

Subscribe here: http://www.nrel.gov/tech_deployment/stat_subscribe.html

Agenda for Today's Webinar

- Basic Introduction to PVWatts

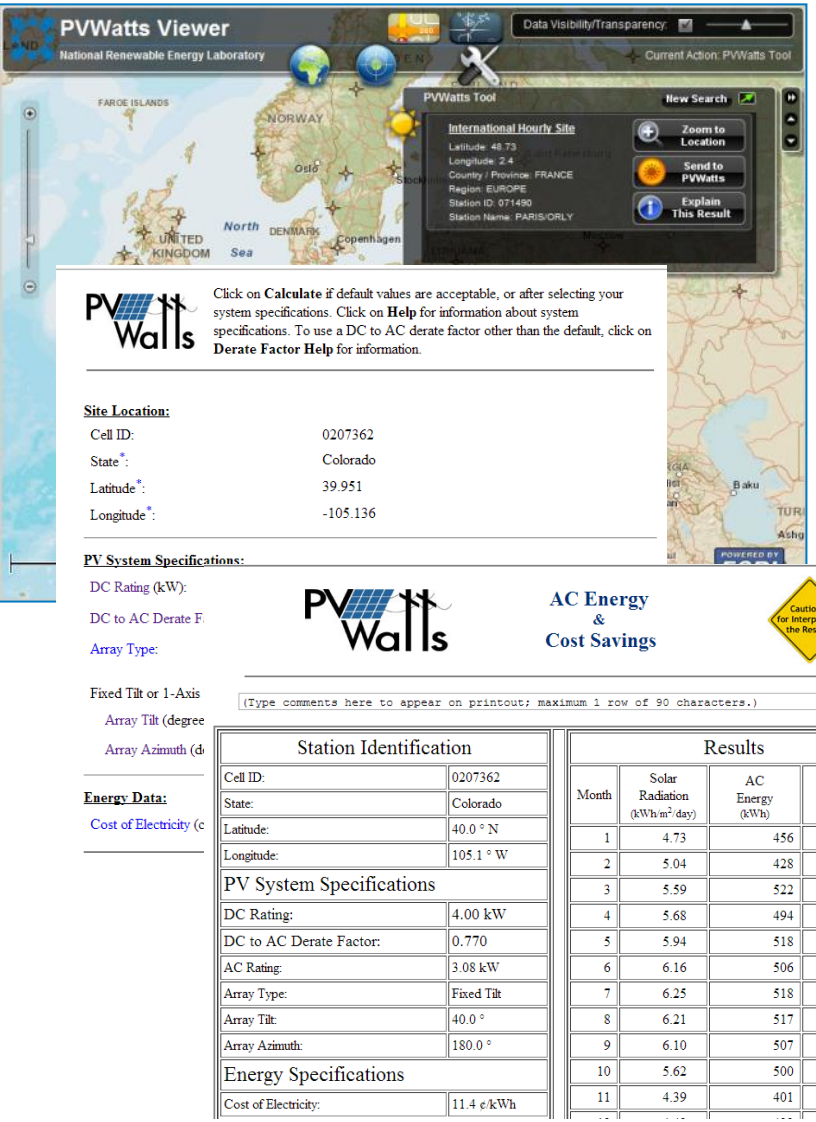
- Demonstration of Existing PVWatts options
  - Version 1 (specific sites using TMY2 weather data)
  - Version 2 (40km gridded data)
  - PVWatts Viewer

- Discussion of Recent and Ongoing Updates present in new version

- Walk through of new version (http://pvwatts.nrel.gov) including hints/tricks along the way

PVWatts

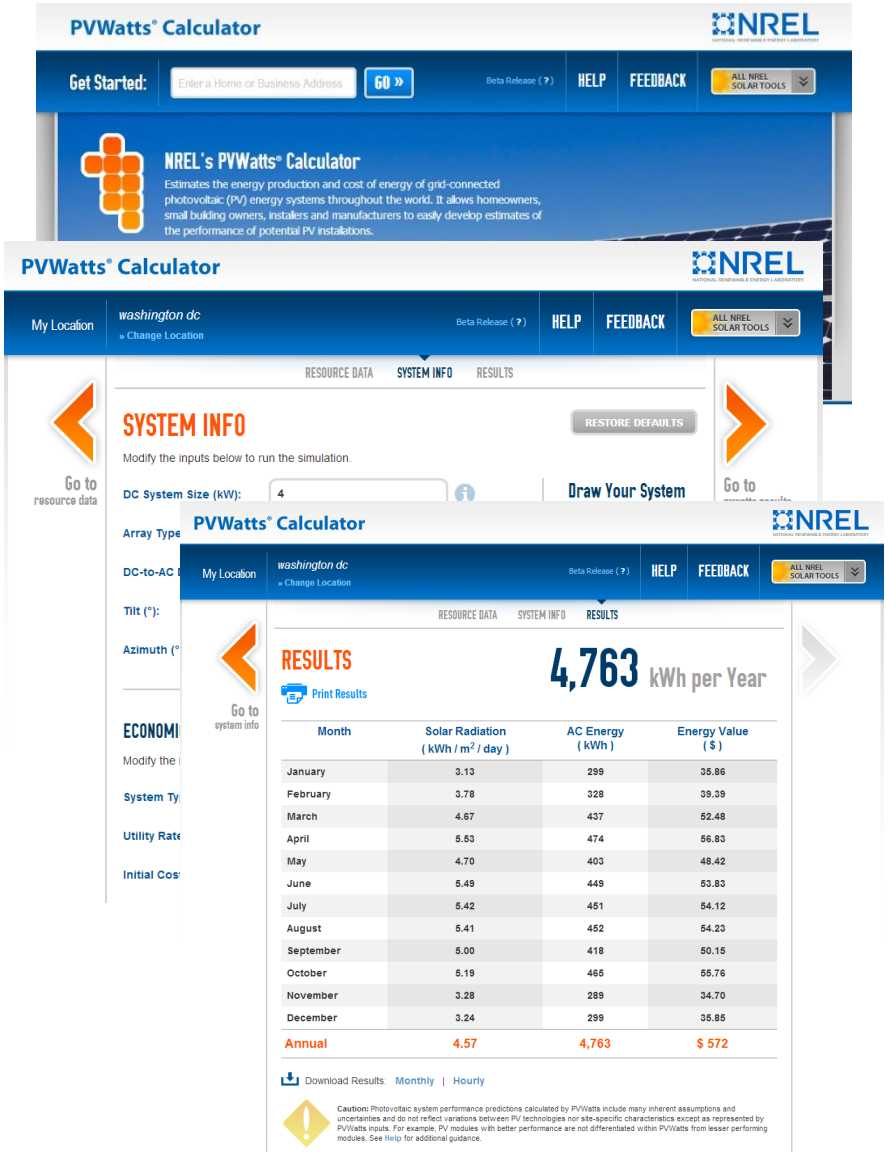
http://gisatnrel.nrel.gov/PVWatts_Viewer



- A calculator for non-experts needing basic solar performance modeling on single structures
- Estimates hourly, monthly and annual PV electric output values
- Comprehensive US coverage and at selected international locations
- One of NREL's most heavily visited sites
- Version 1 launched in 1999
- Version 2 with 40k gridded data launched in 2005

New PVWatts Release

http://pvwattsbeta.nrel.gov



- Updated web tools, etc. compliant with new web requirements
- Maintains goal of quick, accurate answers with minimal inputs
- Incorporates IMBY functionality:
  - Rooftop drawing tool
  - system costs, incentives, cost of energy calculation
  - 10km gridded solar data as an option
- Easy to build on in the future
- Switched from TMY2 weather data to closest TMY3 by default

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Key Model Changes

- Option to select between “Standard”, “Premium”, or “Thin-film” module type
- Option to specify a DC-to-AC nameplate sizing ratio
- System losses are specified as a percentage, default value of 14%. (replaces derate factor)
- Inverter performance curve updated
- One axis tracking systems either estimate linear beam+diffuse self-shading or use backtracking

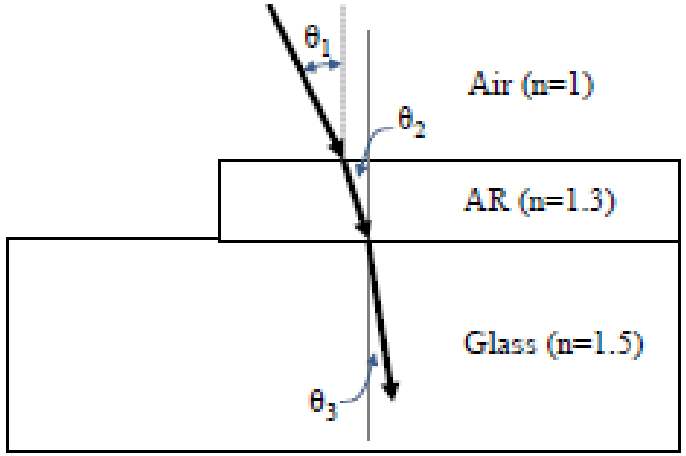
Model Inputs

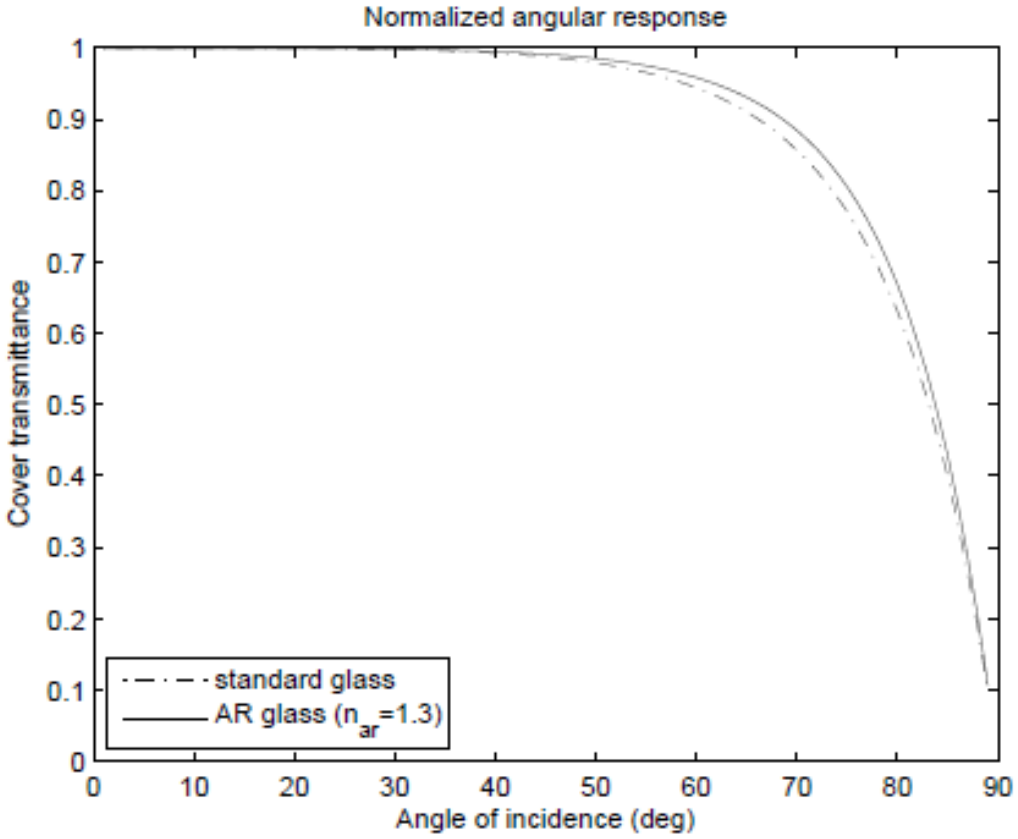
Field	Units	Default Value
System size	kW (DC)	4
Module type	Standard, Premium, Thin film	Standard
System losses	%	14
Array type	Fixed open rack, Fixed roof mount, 1-Axis, Backtracked 1-Axis, 2-Axis	Fixed open rack
Tilt angle	degrees	Site Latitude
Azimuth angle	degrees	180° in northern hemisphere, 0° in southern hemisphere
Advanced inputs		
DC/AC ratio	ratio	1.1
Inverter efficiency	%	96
GCR (1 Axis only)	fraction	0.4

Module Type

Module type	Efficiency	Cover type	Temperature coefficient
Standard	~15 %	Glass	-0.47 %/°C
Premium	~19 %	Anti-reflective	-0.35 %/°C
Thin film	~10 %	Glass	-0.20 %/°C

AR glass model





Thermal Model

- **Fuentes 1986 heat transfer model as in V1**
- **Default open rack mounting system assumes INOCT=45 C**
  - 1 and 2 axis tracking makes open rack assumption
- **Fixed roof mount system assumes 4 inch standoffs, and reduced airflow results in higher INOCT = 49 C**

System Losses

Loss mechanism	Default value
Soiling	2 %
Shading	3 %
Snow	0 %
Mismatch	2 %
Wiring	2 %
Connections	0.5 %
Light-induced degradation	1.5 %
Nameplate rating	1 %
Age	0 %
Availability	3 %
Total losses	14 % (Eqn. 9)

$$L_{total}(\%) = 100\left[1 - \prod_i \left(1 - \frac{L_i}{100}\right)\right]$$

To approximately convert a V5 system loss to a V1 DC-to-AC derate factor:

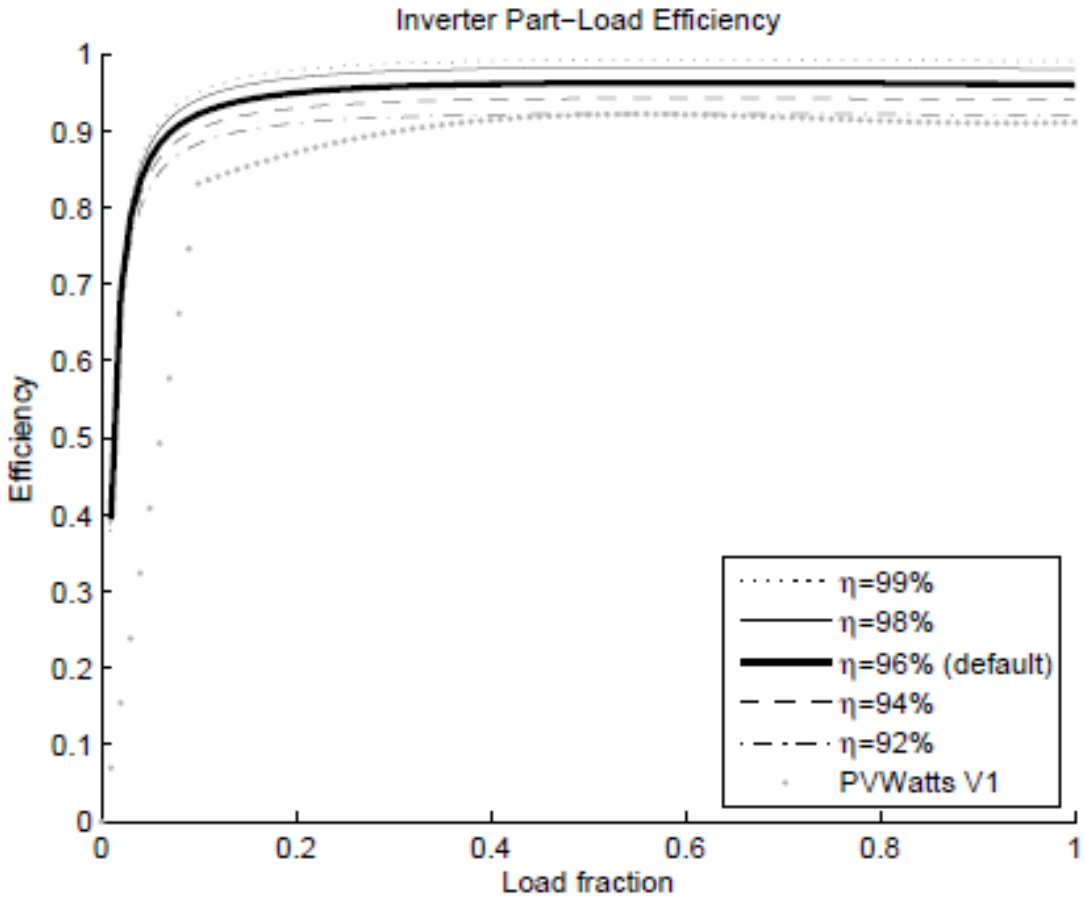
1. Convert the system loss to a derate:
   1 – 14/100 = 0.86
2. Multiply this value by the nominal inverter efficiency:
   0.86 x 0.96 = 0.825

The V5 is thus about 7 % higher than the V1 default of 0.77.

Energy prediction is actually about 8-9% higher due to the revised inverter performance curve.

Inverter

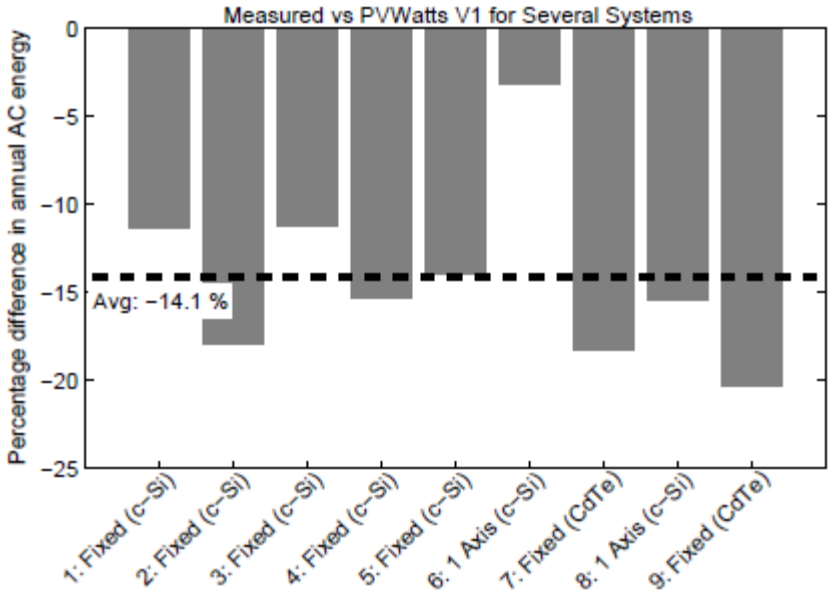
- Based on statistically most representative actual inverter in the CEC database since 2010
- Nominal efficiency can be set by the user, default is 0.96.



$$\eta = \frac{\eta_{nom}}{\eta_{ref}}\left(-0.0109 \cdot \zeta - \frac{0.0051}{\zeta} + 0.9888\right) \quad \text{where} \quad \zeta = \frac{P_{dc}}{P_{dc0}} \quad \text{and} \quad P_{dc0} = \frac{P_{ac0}}{\eta_0}$$

Comparison with Measured Data

- **For nine systems, PVWatts V1 results show predictions are about 14% low**
  - Unshaded systems, hours of bad data or when system is down are removed
- **Zeroing out losses due to shading and availability, the effective V5 derate (slide 6) is 0.877, which is about 13.8 % higher than V1**



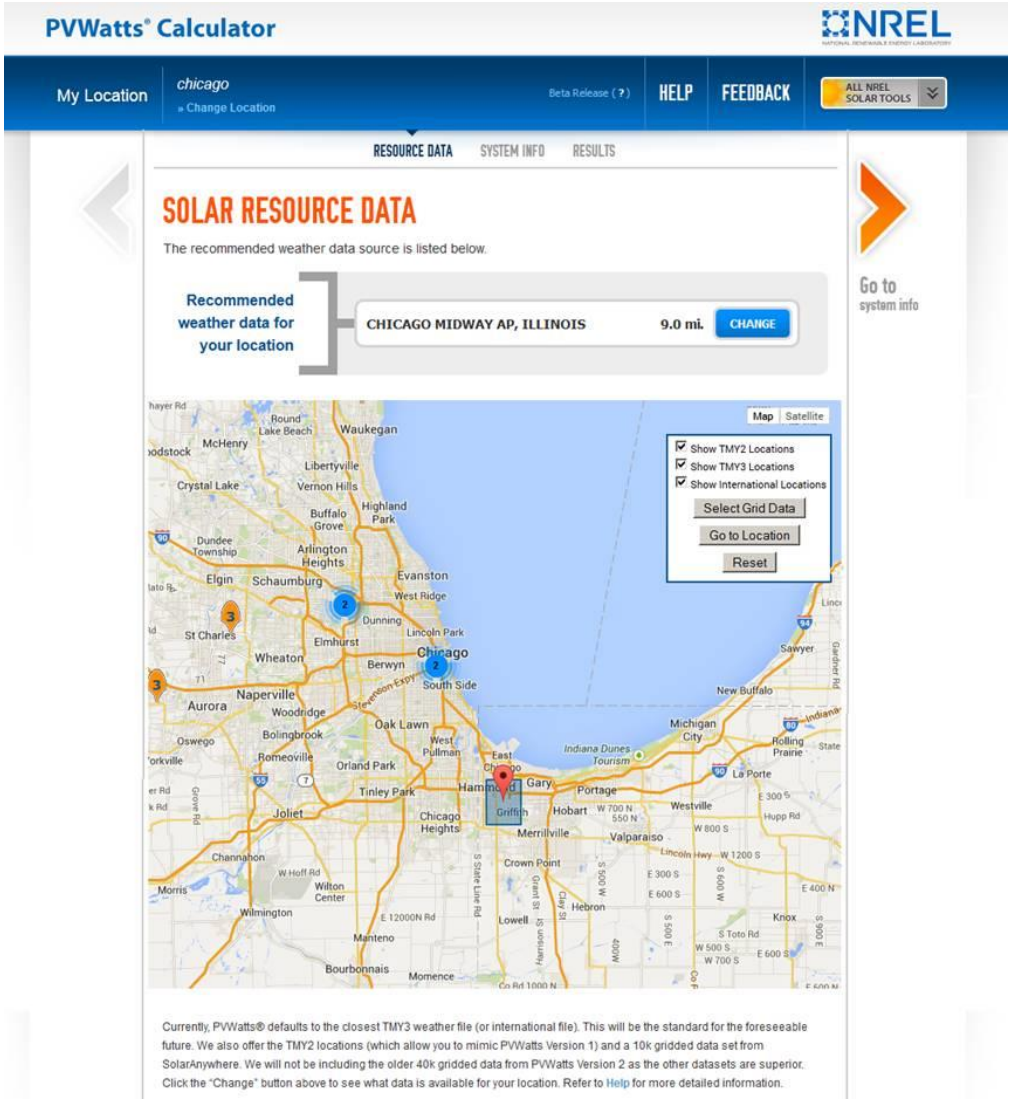
Comparison with V1 for 50 TMY2 sites

- V5 for fixed systems predicts about **7-9% more** energy than V1 with default inputs
- V5 one axis tracking predicts about **5% more** than V1: self shading or backtracking accounts for reduced relative improvement

Location	Fixed	Fixed+Premium	1 Axis	Backtracking	2 Axis
AK Anchorage	14.7 %	14.3 %	6.8 %	8.0 %	9.6 %
AL Huntsville	9.7 %	11.2 %	4.9 %	5.9 %	8.5 %
AR Little Rock	9.8 %	11.5 %	4.7 %	5.6 %	8.5 %
AZ Phoenix	8.8 %	12.1 %	3.7 %	3.9 %	8.0 %
CA Sacramento	9.2 %	11.2 %	4.0 %	4.5 %	8.2 %
CO Boulder	8.9 %	10.2 %	3.3 %	3.9 %	7.3 %
CT Hartford	10.2 %	10.7 %	5.0 %	6.3 %	8.0 %
DE Wilmington	9.9 %	10.8 %	4.9 %	5.9 %	8.3 %
FL Miami	9.4 %	11.5 %	4.7 %	5.7 %	8.3 %
GA Atlanta	9.5 %	11.0 %	4.6 %	5.4 %	8.4 %
HI Honolulu	8.7 %	10.9 %	3.0 %	3.4 %	7.8 %
IA Des Moines	9.6 %	10.3 %	4.2 %	4.9 %	8.0 %
ID Boise	9.4 %	10.6 %	3.2 %	3.6 %	8.1 %
IL Chicago	10.1 %	10.7 %	4.7 %	5.7 %	8.4 %
IN Indianapolis	10.0 %	10.8 %	4.9 %	6.0 %	8.5 %
KS Wichita	9.3 %	10.4 %	4.0 %	4.6 %	8.0 %
KY Lexington	10.1 %	11.0 %	5.0 %	6.0 %	8.7 %
LA New Orleans	9.9 %	11.8 %	5.3 %	6.4 %	8.6 %
MA Boston	9.8 %	10.2 %	4.7 %	5.7 %	8.0 %
MD Baltimore	10.0 %	10.9 %	4.9 %	5.9 %	8.4 %
ME Portland	9.6 %	9.8 %	3.9 %	4.8 %	6.9 %
MI Detroit	10.5 %	10.9 %	4.9 %	6.1 %	8.2 %
MN Minneapolis	9.5 %	9.8 %	3.7 %	4.5 %	6.9 %
MO Springfield	9.6 %	10.8 %	4.4 %	5.1 %	8.3 %
MS Jackson	9.8 %	11.6 %	5.2 %	6.2 %	8.5 %
MT Great Falls	9.7 %	10.1 %	3.5 %	4.2 %	7.3 %
NC Charlotte	9.7 %	11.2 %	4.9 %	5.8 %	8.5 %
ND Fargo	9.6 %	9.6 %	3.3 %	4.1 %	6.6 %
NE Omaha	9.5 %	10.4 %	4.2 %	5.0 %	7.5 %
NH Concord	9.8 %	10.3 %	4.3 %	5.2 %	7.6 %
NJ Newark	10.2 %	10.8 %	5.3 %	6.4 %	8.6 %
NM Albuquerque	8.5 %	10.3 %	3.6 %	4.0 %	7.6 %
NV Las Vegas	8.5 %	11.2 %	3.0 %	3.1 %	7.8 %
NY Albany	10.2 %	10.6 %	4.4 %	5.4 %	8.0 %
OH Cleveland	10.8 %	11.4 %	5.3 %	6.5 %	8.6 %
OK Tulsa	9.5 %	10.8 %	4.2 %	4.9 %	8.4 %
OR Portland	11.6 %	12.6 %	5.6 %	6.6 %	9.9 %
PA Harrisburg	10.0 %	10.9 %	5.0 %	6.0 %	8.6 %
RI Providence	9.8 %	10.2 %	4.8 %	5.8 %	8.1 %
SC Charleston	9.5 %	11.1 %	4.7 %	5.5 %	8.4 %
SD Sioux Falls	9.6 %	10.1 %	3.8 %	4.5 %	7.1 %
TN Chattanooga	10.1 %	11.7 %	5.4 %	6.4 %	9.0 %
TX Abilene	8.9 %	10.6 %	3.6 %	4.1 %	7.9 %
UT Salt Lake City	9.4 %	10.9 %	3.6 %	4.1 %	7.8 %
VA Richmond	9.8 %	10.9 %	4.8 %	5.7 %	8.4 %
VT Burlington	10.1 %	10.3 %	4.1 %	5.1 %	7.4 %
WA Yakima	9.8 %	11.2 %	3.3 %	3.7 %	8.1 %
WI Madison	9.9 %	10.2 %	4.6 %	5.7 %	7.8 %
WV Elkins	10.7 %	11.3 %	5.9 %	7.4 %	9.0 %
WY Cheyenne	8.8 %	9.2 %	2.9 %	3.4 %	7.2 %
Average	9.8 %	10.9 %	4.4 %	5.3 %	8.1 %

Map-Based Weather Data Selection

- Allows the user to visually select a weather file other than the default TMY3 file.
- Supports TMY2, TMY3, International files, and 10km gridded SolarAnywhere® by CPR® data.



General Deployment Plan

- Coding essentially complete
- Currently doing final internal and external reviews (industry reviews are positive)
- Update the website and web service for http://pvwatts.nrel.gov hopefully in July 2014
- Leave the old V1 and V2 sites running until end of calendar year to ease the transition to users

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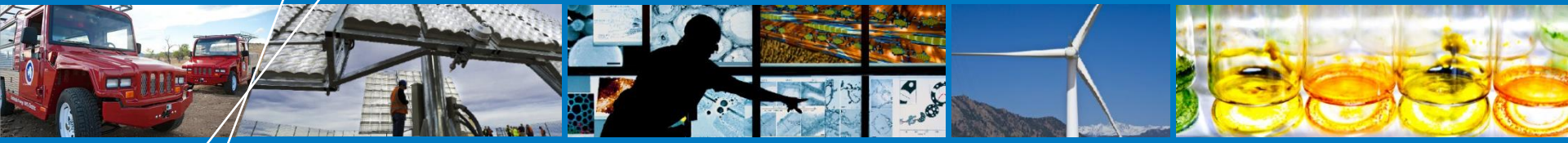

Questions?

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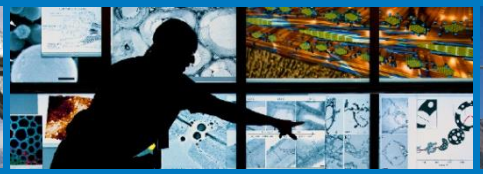

Thank You!

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